WATER QUALITY STATUS REPORT NO. 85
CITIZEN'S VOLUNTEER MONITORING PROGRAM

CASCADE RESERVOIR
Valley County, Idaho
1988

Idaho Department of Health and Welfare
Division of Environmental Quality
Water Quality Bureau
Boise, Idaho

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ABSTRACT

A Citizen Lake Monitoring Program was initiated for Cascade Reservoir during the summer of 1988. The program was conducted by volunteers with the Cascade Reservoir Association, a citizen group comprised of lake property owners and supporters for improved water quality in the reservoir. Four lake stations were samples monthly from June through October for nutrients, chlorophyll a, Secchi disk depth, and dissolved oxygen. Field readings were taken for the Secchi disk depth and the dissolved oxygen concentration; water samples were preserved and transported to the State of Idaho laboratory in Boise for nutrient and chlorophyll a analyses. The station located in the North Fork arm of the reservoir had the lowest nutrient values and the lowest chlorophyll a values, and therefore the overall best water quality. The quality of water progressively decreased as it moved through the reservoir towards the outlet. The station located near the outlet at the dam had the lowest dissolved oxygen readings, the shallowest Secchi disk readings, the highest nutrient results, and the highest chlorophyll a readings. The chlorophyll a levels at the dam station rose steadily over the summer from 17.8 µg/L in June to 55.1 µg/L during October. No trends were readily apparent between the data collected in 1988 and data previously collected from the reservoir. Although the Secchi disk readings appear to be lower in 1988 than in previous years it is not apparent if this is a trend or merely a reflection of the extreme conditions for the reservoir during 1988, following two drought years.

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GLOSSARY

Aerobic - living or active only in the presence of oxygen; with oxygen.

Anaerobic - living or active in the absence of oxygen; without oxygen.

Anoxic - a condition of no oxygen in the water. Often occurs near the bottom of fertile stratified lakes in the summer and under ice cover in the winter.

Chlorophyll - the green pigment of plants necessary for photosynthesis.

Chlorophyll a - a type of chlorophyll present in all types of algae, sometimes in direct proportion to the biomass of algae.

Dissolved oxygen - the oxygen dissolved in water and readily available to aquatic organisms.

Epilimnion - the upper waters of a thermally stratified lake subject to wind action.

Eutrophic - from Greek for "well-nourished," describes a lake of high photosynthetic activity and low transparency.

Hypereutrophic - from Greek for "over-nourished," describes a lake of excessively high productivity

Hypolimnion - the bottom waters of a thermally stratified lake. The hypolimnion of a eutrophic lake is usually low or lacking in oxygen.

Inorganic nitrogen - the sum of ammonia, nitrite, and nitrate nitrogen.

Milligrams per liter (mg/L) - a unit for expressing the concentration of chemical constituents in solution. Milligrams per liter represents the mass of solute per unit volume (liter) of water. It is roughly equivalent to parts per million.

Micrograms per liter (µg/L) - a unit expressing the concentration of chemical constituents in solution as mass (micrograms) of solute per unit volume (liter) of water. It is roughly equivalent to parts per billion.

Mesotrophic - the middle range between oligotrophic and eutrophic; a lake that is moderately nourished.

Oligotrophic - from Greek for "poorly nourished," describes a lake of low plant productivity and high transparency.

INTRODUCTION

A Citizen Volunteer Water Quality Monitoring Program was initiated for Cascade Reservoir during the summer of 1988. The program was conducted by volunteers with the Cascade Reservoir Association (CRA), a citizen group comprised of lake property owners and supporters for improved water quality in the reservoir.

The initiation of this program filled a vital need for acquiring current lake water quality data. Reservoir water samples had not been collected from the lake for six years. Furthermore, the samples will help establish trends for predicting long term changes in ambient water quality.

METHODS

Four lake stations, two of which coincided with stations previously monitored by Clark and Wroten (1975) and Zimmer (1983), were selected for monitoring. The stations were: 1) in the North Fork Payette River arm, 2) across from the Poison Creek boat launch, 3) west of Sugarloaf Island, and 4) near the buoy line at the dam. Figure 1 depicts the locations of the monitoring stations.

The monitoring focused on the main parameters of concern in the reservoir which are nutrients, chlorophyll a, water transparency or Secchi disk depth, and dissolved oxygen.

The Division of Environmental Quality, Water Quality Bureau provided a day long training for the citizens in use of the equipment, and proper sample collection and handling techniques.

The CRA provided their own boats and one set of sampling equipment. The equipment included a Kemmerer bottle, a Secchi disk, and a Hach dissolved oxygen test kit. A second set of equipment was loaned by the Division of Environmental Quality.

Sampling was scheduled to occur once a month from June through September, for a total of four sample sets. The September sampling date actually ended up being the first weekend in October. Two samples were collected at each station. One sample was collected in the epilimnion, at the Secchi disk transparency depth, and a hypolimnetic sample was obtained from one meter off the reservoir bottom.

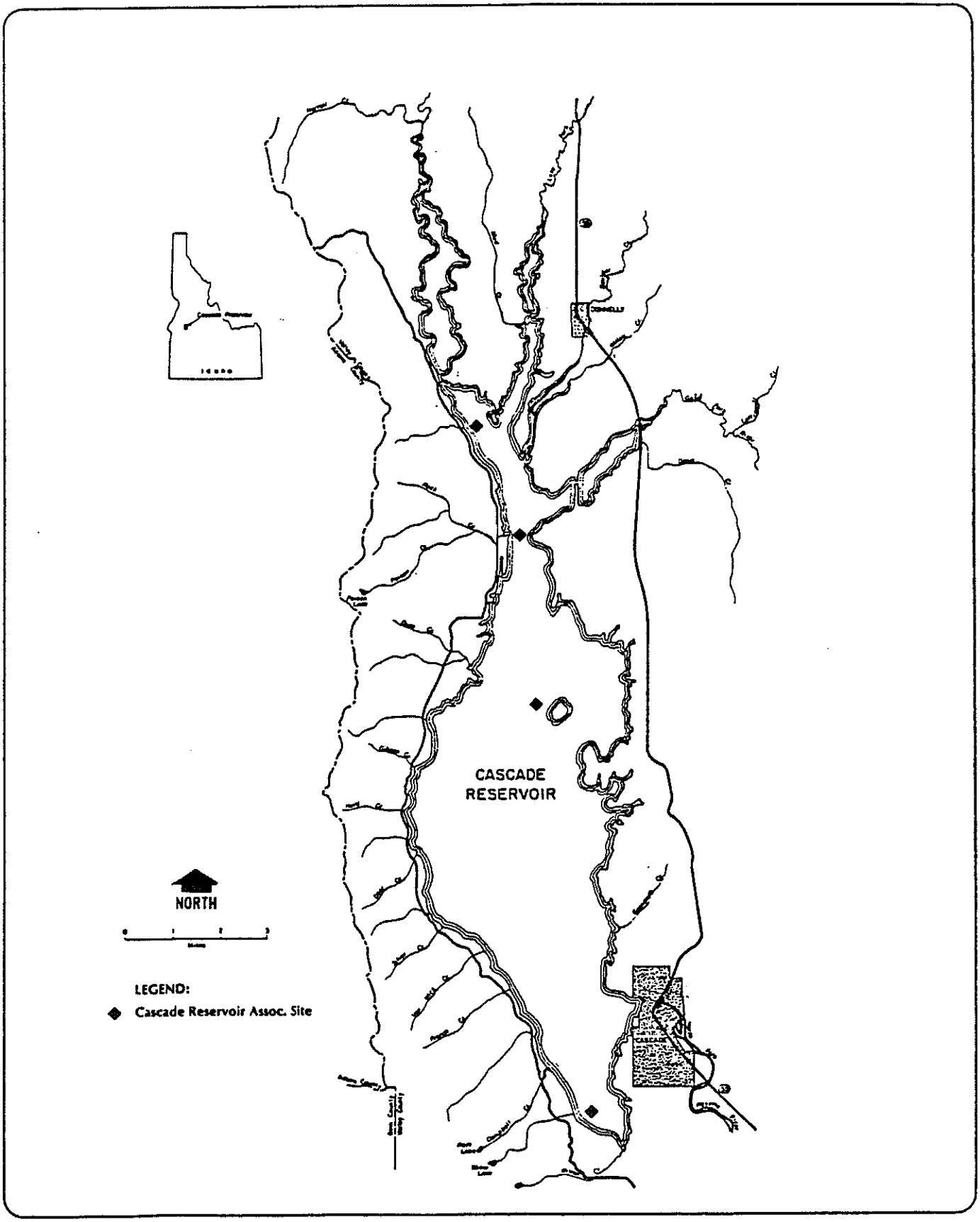

Figure 1. Monitoring stations for the Citizen Volunteer Water Quality Monitoring Program on Cascade Reservoir during 1988.
(Map courtesy of ENTRANCO Engineers, Kirkland ,WA)

Field readings were taken for the Secchi disk transparency depth and the dissolved oxygen concentration. The water samples were preserved and transported to the State of Idaho Bureau of Laboratories in Boise for nutrient and chlorophyll a analyses.

TROPHIC CLASSIFICATION

Table 1 is an example of a trophic classification system. Lakes can be classified according to their trophic status, or biological productivity. Unproductive lakes are classified as oligotrophic, and highly productive lakes are termed eutrophic or even hyper-eutrophic (Burr et al. 1987).

Lake productivity is regulated by many chemical and physical factors, but probably the most important of these is the input of nutrients from external sources. Lakes with very little nitrogen or phosphorus in biologically available forms will not be very productive. Phosphorus, in particular, is the single most important factor in determining lake productivity or trophic status (EPA 1988).

Furthermore, the term eutrophication is synonymous with increased growth rates of the biota of lakes. The most basic and accurately measurable criterion of accelerated productivity is increasing rates of annual photosynthesis by algae (Wetzel 1975). Chlorophyll a is present in all algae and is the most widely accepted indicator of algal density.

This table can be used to classify Cascade Reservoir's measured in-lake variables to its trophic state.

Table 1. Trophic classification system

General Level of Productivity	Phosphorus (mg/L)	Chlorophyll a (µg/L	Secchi disk Depth (meters)	Inorganic N (mg/L)
oligotrophic	0.003-0.009	0.3-2	7.0-16	0.2-0.4
mesotrophic	0.009-0.024	2-6.0	2.0-6	0.3-0.6
eutrophic	0.024-0.075	6.0-40	0.75-2	0.5-1.5
hyper-eutrophic	>0.065	>40	<0.75	>1.5

From: Wetzel 1975. Limnology and Wetzel 1983. Limnology (2nd Edition)

RESULTS AND DISCUSSION

A complete tabulation of all the results for 1988 is contained in Appendix A. The results are presented for each station, and are also compiled to show Secchi disk depth results and bottom sample results separately.

A brief discussion of the results for each station, progressing from north to south along the reservoir, follows.

1) NORTH FORK ARM

This station, located in the arm of the reservoir formed by the North Fork Payette River, is the shallowest of all the stations. At its maximum depth in June it was 5.5 meters deep and by October the maximum depth was 2.5 meters. The October hypolimnetic sample, which was to be collected one meter off the bottom at 1.5 meters, was higher than the Secchi disk transparency depth, which was 2 meters. Therefore, only one sample from 2 meters depth was collected.

This station is probably somewhat reflective of the inflow from the North Fork Payette River. The station is too shallow for stratification to occur. The lowest dissolved oxygen reading was 8 mg/L taken at 3.5 meters depth in July. Generally, the dissolved oxygen was between 10 and 11 mg/L.

This station had the lowest nutrient values and the lowest chlorophyll a values, and thus the overall best water quality.

2) POISON CREEK

The depth of this station decreased from a maximum of 9.5 meters in June down to 5.5 meters in October. The lowest dissolved oxygen reading in the hypolimnion was 5.0 mg/L in July. The August and October values were 12 mg/L and 11 mg/L respectively, indicating that stratification had not set up and that possibly some wind mixing was occurring.

The nutrient levels from this station were all quite low, also indicative of aerobic conditions throughout the water column. The total phosphorus readings for each sample were at the detection limit or barely above it. The lowest chlorophyll a value was 5.0 µg/L and this corresponded to the deepest Secchi disk reading of 2.5 meters. Chlorophyll a increased over the course of the summer to 30 µg/l in October (Figure 2).

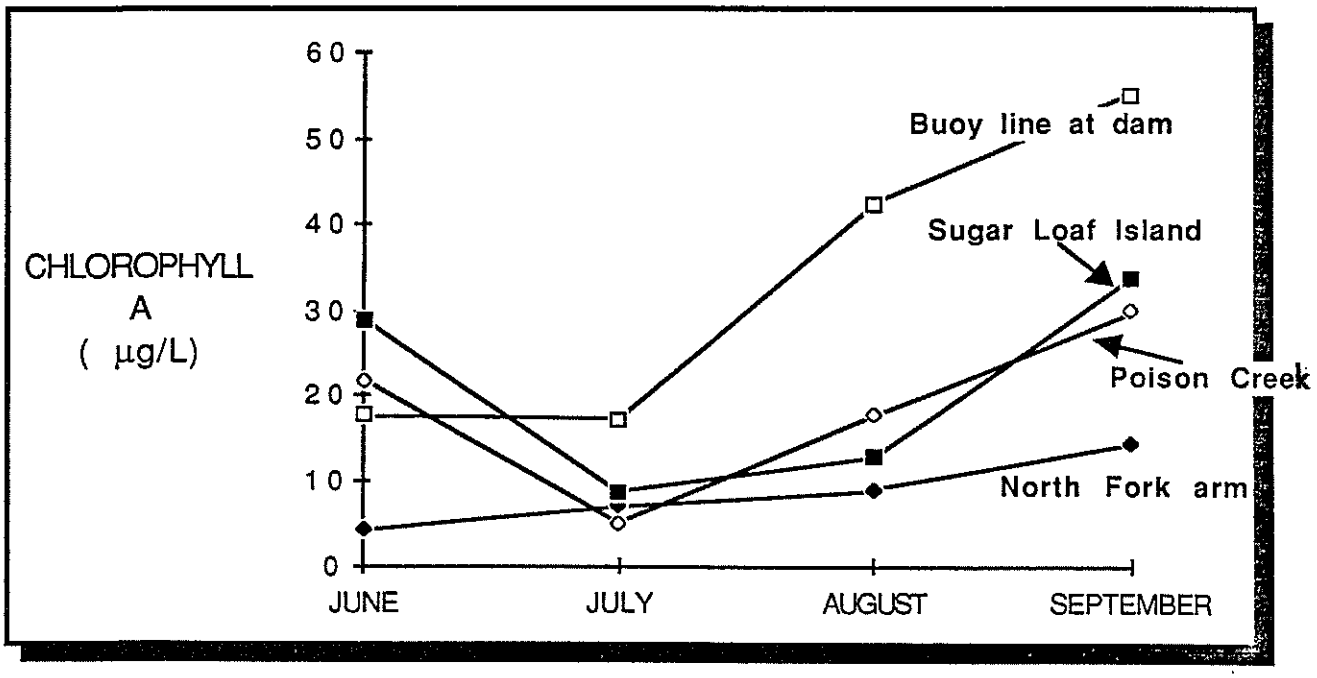

Figure 2. Chlorophyll a values for Cascade Reservoir during 1988.

3) SUGARLOAF ISLAND

The depth of this station decreased from a maximum of 16 meters down to 8.5 meters in October. A water sample collected from 15 meters depth in July had only 0.7 mg/L oxygen, the only time the hypolimnion was anaerobic. The highest hypolimnetic nutrient readings were obtained at this time also, indicating that nutrients were being released from the sediments into the bottom waters. However, it is unlikely the nutrients were being transferred to the epilimnion at this time, due to the low nutrient values for the surface sample collected at the same time.

The value of 0.7 mg/L dissolved oxygen indicates that this depth of the reservoir water column was inhabitable by either warmwater or coldwater fish. The fish would have to move to an area of higher oxygen concentration, if available.

The deepest Secchi disk reading was 2.5 meters and was obtained in July. This corresponds with the lowest chlorophyll a value of 8.7 µg/L. Like the other stations, chlorophyll a values rose steadily all summer and peaked at 33.9 µg/L in October (Figure 2).

4) BUOY LINE AT DAM

This station, which is located at the deepest part of the reservoir, is the least impacted by the reservoir drawdown. This station experienced a total change in depth of only 2-3 meters, dropping to 15.5 meters in October from 17.4 meters in June. This station is most reflective of average conditions throughout the southern reservoir due to its location and depth.

The data for this station indicate the greatest extremes of all the stations sampled. It had the lowest dissolved oxygen levels, the shallowest Secchi disk reading, the highest nutrient results, and the highest chlorophyll a readings. The chlorophyll a levels rose steadily over the summer from 17.8 µg/L in June to 55.1 µg/L during October.

The hypolimnion was anoxic during July and August. As a result, the nutrient concentrations in the bottom waters increased over this period due to the anaerobic release of nutrients from the sediment. When the dissolved oxygen level came back up to 4.5 mg/L in October the nutrient levels dropped.

The July and August hypolimnetic dissolved oxygen levels near the dam exceeded the U. S. Environmental Protection Agency's (EPA) dissolved oxygen criteria for both coldwater fish and warmwater fish (Table 2). The criteria listed in Table 2 are estimates of the threshold concentration for dissolved oxygen below which detrimental effects are expected. If the dissolved oxygen concentration is at or above these levels then the EPA believes a reasonable

and adequate degree of protection is provided for freshwater aquatic life (EPA 1986).

Based on the hypolimnetic dissolved oxygen concentrations, this portion of the reservoir would have been inhabitable for either coldwater or warmwater fish for what appears to be two months.

Table 2. Water quality criteria for ambient dissolved oxygen concentrations. Values are expressed in milligrams per liter (EPA 1986).

	Coldwater criteria		Warmwater Criteria	
	Early life stages[1]	Other life stages	Early life stages	Other life stages
30 Day mean	NA[2]	6.5	NA	5.5
7 Day Mean	6.5	NA	6.0	NA
7 Day Mean Minimum	NA	5.0	NA	4.0
1 Day Minimum[3]	5.0	4.0	5.0	3.0

1 Includes all embryonic and larval stages and all juvenile forms to 30-days following hatching.
2 Not applicable
3 All minima should be considered as instantaneous concentrations to be achieved at all times.

SUMMARY

The data indicate a general decrease in the quality of water as it moves through the reservoir towards the outlet. The quality of water in the North Fork arm of the reservoir was generally better, with lower nutrient and chlorophyll a levels and higher dissolved oxygen values, than the quality of water at the southern end of the reservoir.

The chlorophyll a values from 1988, as depicted in Figure 2, indicate this trend. The North Fork arm station had the lowest chlorophyll a levels and the buoy line at the dam had the highest levels during each sampling event.

This difference in water quality is to be expected due to the increased residence time for waters sampled in the southern end of the reservoir. There is more opportunity for nutrient utilization and algal growth in the deep, southern end of the reservoir. Also, the deeper portion of the reservoir allows stratification to occur which contributes to low hypolimnetic dissolved oxygen readings and sediment nutrient releases.

COMPARISON WITH PREVIOUS DATA

The only station that was consistently sampled at roughly the same location over the past 12 years was the buoy line at the dam. As previously mentioned, this station is the best indicator of conditions in the reservoir due to the depth and location of the station in relation to the remainder of the reservoir.

Table 3 is a summary of the data from this station since 1975. The data were compiled from Clark and Wroten (1975) and Zimmer (1983). One early summer sample (eg. June) and a late summer sample (eg. August) were tabulated from each year monitoring occurred.

No trends were readily apparent with the data. Low dissolved oxygen concentrations have been reported since 1975 (Klahr 1986). The data depict a seasonal cycle typical for productive lakes in a temperate climate. The bottom waters are oxygenated in June and anaerobic by August (Figure 3). This physical situation has a reverse impact on the nutrient values; as oxygen is depleted the nutrient values increase.

Figure 4 depicts the Secchi disk transparency depths over the past 13 years. There appears to be a negative trend in the depths, or they are shallower in 1988 than in previous years. However, there are not enough data to indicate if this will be a continuing situation or merely a reflection of the extreme conditions for the reservoir during the drought of 1988.

Table 3. Water quality data taken from the station located near the buoy line at the dam at Cascade Reservoir, Valley County, Idaho. Data compiled from Clark and Wroten (1975), Zimmer (1983), and the citizen monitoring program for 1988.

DATE	Total Phos. (mg/L)		SECCHI	CHL. A	DO (mg/L)	T. Inorg. Nit.(mg/L)	
	(top)	(bottom)	Depth (M)	(µg/L)	(bottom)	(top)	(bottom)
Jun-75			2.4	3.4	4.5	0.04	0.05
Aug-75			2.7	12.0	0.5	0.06	0.16
Aug-78	0.06	0.23	1.3	119.6	0.1	0.01	0.20
Jun-79	0.03	0.25	3.9	0.7	0.1	0.07	0.47
Aug-79	0.06	0.35	1.3	35.8	0.2	0.03	0.66
Jun-80	0.02	0.04	3.7	3.1	7.1	0.04	0.05
Aug-80	0.02	0.16	3.4	7.0	0.2	0.11	0.34
Jun-81	0.01	0.02	4.0	2.7	2.3		
Sep-81	0.03	0.22	4.2	2.0	0.1		
Jun-88	0.05	0.06	2.0	17.8	5.8	0.041	0.11
Aug-88	0.05	0.33	1.0	42.2	0.5	0.064	0.54

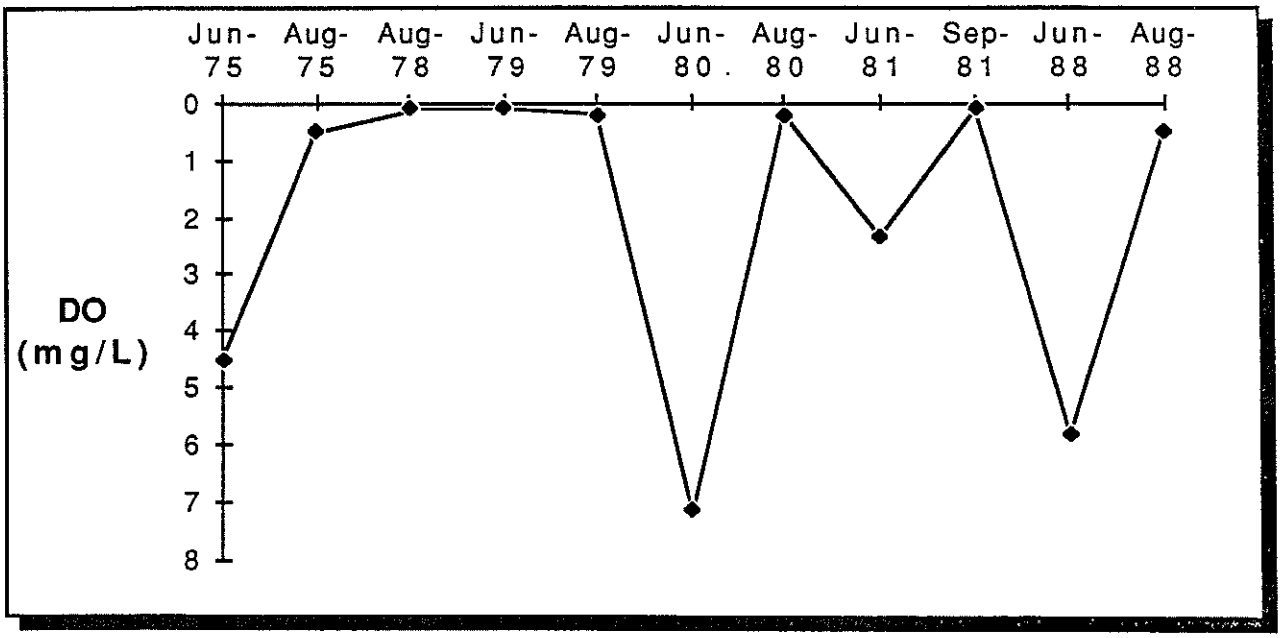

Figure 3. Hypolimnetic dissolved oxygen readings taken near the dam at Cascade Reservoir from 1975-1988.

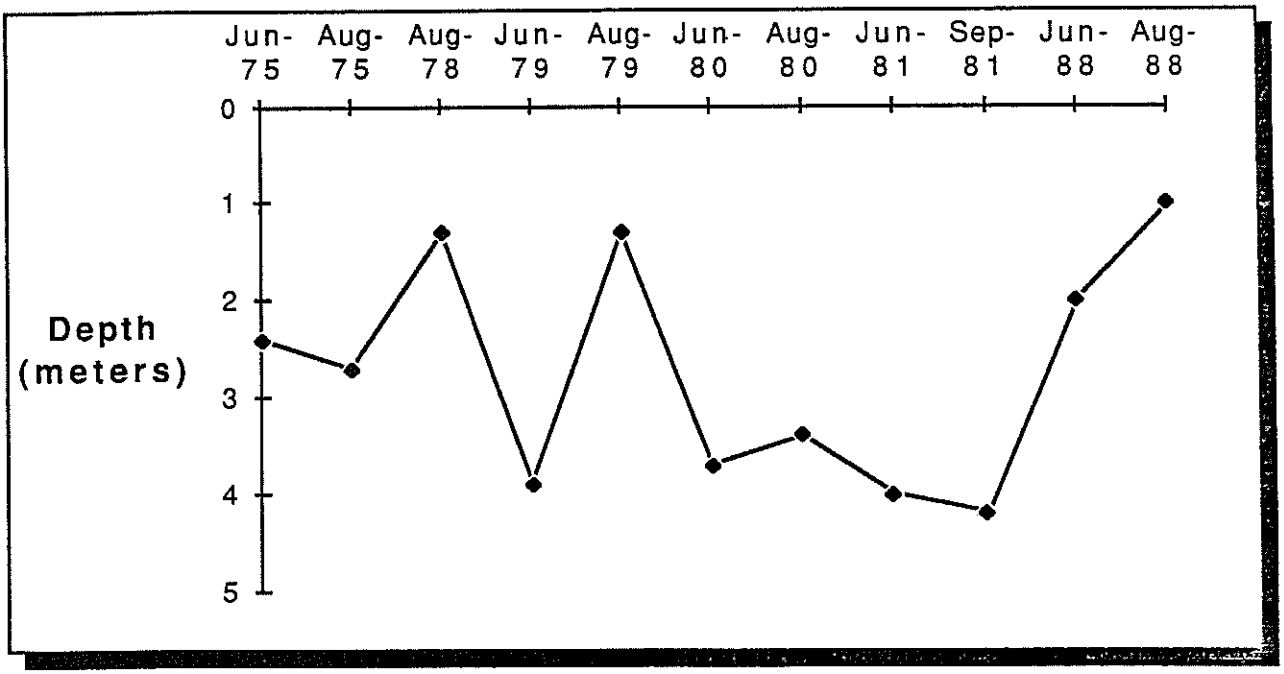

Figure 4. Secchi disk readings from 1975-1988 taken near the dam at Cascade Reservoir.

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APPENDIX A

Water Quality data for the NORTH FORK ARM of Cascade Reservoir during 1988.

Date	Sample depth (meters)	Chloro. A (µg/L)	Ammonia (mg/L)	NO2 + NO3 (mg/L)	T. Nitrogen (mg/L)	T. Phos. (mg/L)	Ortho Phos. (mg/L)	Diss. Oxygen (mg/L)
June	1.75	4.2	0.022	0.008	0.13	<0.05	0.001	11.0
	4.50		0.022	0.009	0.14	<0.05	0.002	11.0
July	1.25	7.0	0.017	0.017	0.39	<0.05	0.001	
	3.50		0.015	0.008	0.44	<0.05	0.003	8.0
August	1.25	9.0	0.026	0.064	0.42	0.05	0.009	10.0
	2.00		0.029	0.059	0.43	0.05	0.100	11.0
October	2.00	14.5	0.010	0.006	0.24	<0.05	0.018	11.0

NORTH FORK ARM (Secchi disk depths only)

Date	Secchi depth (meters)	Chloro. A (µg/L)	Ammonia (mg/L)	NO2 + NO3 (mg/L)	T. Nitrogen (mg/L)	T. Phos. (mg/L)	Ortho Phos. (mg/L)	Diss. Oxygen (mg/L)
June	1.75	4.2	0.022	0.008	0.13	<0.05	0.001	11.0
July	1.25	7.0	0.017	0.017	0.39	<0.05	0.001	
August	1.25	9.0	0.026	0.064	0.42	0.05	0.009	10.0
October	1.25	14.5	0.01	0.006	0.24	<0.05	0.018	11.0

NORTH FORK ARM (One meter off bottom)

Date	Sample depth (meters)		Ammonia (mg/L)	NO2 + NO3 (mg/L)	T. Nitrogen (mg/L)	T. Phos. (mg/L)	Ortho Phos. (mg/L)	Diss. Oxygen (mg/L)
June	4.50		0.022	0.009	0.14	<0.05	0.002	11.0
July	3.50		0.015	0.008	0.44	<0.05	0.003	8.0
August	2.00		0.029	0.059	0.43	0.05	0.100	11.0
October	2.00							11.0

Water quality data for the POISON CREEK station on Cascade Reservoir during 1988.

Date	Sample depth (meters)	Chloro. A (µg/L)	Ammonia (mg/L)	NO2 + NO3 (mg/L)	T. Nitrogen (mg/L)	T. Phos. (mg/L)	Ortho Phos. (mg/L)	Diss. Oxygen (mg/L)
June	1.50	21.9	0.051	0.054	0.40	<0.05	0.002	11.0
	8.50		0.066	0.040	0.32	<0.05	0.002	12.0
July	2.50	5.0	0.037	<0.001	0.47	<0.05	0.003	
	7.25		0.035	<0.001	0.57	0.06	0.003	5.0
August	1.25	17.8	0.014	0.032	0.59	<0.05	0.004	9.0
	5.50		0.096	0.026	0.65	0.06	0.011	12.0
October	1.25	30	0.037	0.002	0.59	0.08	0.007	11
	4.50		0.028	0.003	0.52	0.06	0.006	11

POISON CREEK (Secchi disk depths only)

Date	Secchi depth (meters)	Chloro. A (µg/L)	Ammonia (mg/L)	NO2 + NO3 (mg/L)	T. Nitrogen (mg/L)	T. Phos. (mg/L)	Ortho Phos. (mg/L)	Diss. Oxygen (mg/L)
June	1.50	21.9	0.051	0.054	0.40	<0.05	0.002	11.0
July	2.50	5.0	0.037	<0.001	0.47	<0.05	0.003	
August	1.25	17.8	0.014	0.032	0.59	<0.05	0.004	9.0
October	1.25	30	0.037	0.002	0.59	0.08	0.007	11.0

POISON CREEK (One meter off bottom)

Date	Sample depth (meters)		Ammonia (mg/L)	NO2 + NO3 (mg/L)	T. Nitrogen (mg/L)	T. Phos. (mg/L)	Ortho Phos. (mg/L)	Diss. Oxygen (mg/L)
June	8.50		0.066	0.040	0.32	<0.05	0.002	12.0
July	7.25		0.035	<0.001	0.57	0.06	0.003	5.0
August	6.50		0.096	0.026	0.65	0.06	0.011	12.0
October	4.5		0.028	0.003	0.52	0.06	0.006	11.0

Water quality data for the SUGARLOAF ISLAND station on Cascade Reservoir during 1988.

Date	Sample depth (meters)	Chloro. A (µg/L)	T. Ammonia (mg/L)	NO2 + NO3 (mg/L)	T. Nitrogen (mg/L)	T. Phos. (mg/L)	Ortho Phos. (mg/L)	Diss. Oxygen (mg/L)
JUNE	1.50	29.0	0.022	<0.001	0.39	<0.05	0.004	
	10.00		0.041	0.001	0.41	0.05	0.005	
JULY	2.50	8.7	0.059	0.009	0.45	<0.05	0.005	9.0
	15.00		0.346	<0.001	1.59	0.36	0.015	0.7
AUGUST	1.50	12.9	0.018	0.017	0.56	<0.05	0.004	7.0
	8.25		0.171	0.014	0.68	0.09	0.011	2.5
OCTOBER	1.50	33.9	0.018	0.037	0.76	0.06	0.004	9.2
	7.50		0.010	<0.001	0.71	0.06	0.002	7.8

SUGARLOAF ISLAND (Secchi disk depth)

Date	Secchi depth (meters)	Chloro. A (µg/L)	T. Ammonia (mg/L)	NO2 + NO3 (mg/L)	T. Nitrogen (mg/L)	T. Phos. (mg/L)	Ortho Phos. (mg/L)	Diss. Oxygen (mg/L)
JUNE	1.50	29.0	0.022	<0.001	0.39	<0.05	0.004	
JULY	2.50	8.7	0.059	0.009	0.45	<0.05	0.005	9.0
AUGUST	1.50	12.9	0.018	0.017	0.56	<0.05	0.004	7.0
OCTOBER	1.50	33.9	0.018	0.037	0.76	0.06	0.004	9.2

SUGARLOAF ISLAND (One meter off bottom)

Date	Sample depth (meters)		T. Ammonia (mg/L)	NO2 + NO3 (mg/L)	T. Nitrogen mg/L)	T. Phos. (mg/L)	Ortho Phos. (mg/L)	Diss. Oxygen (mg/L)
JUNE	10.00		0.041	0.001	0.41	0.05	0.005	
JULY	15.00		0.346	<0.001	1.59	0.36	0.015	0.7
AUGUST	8.25		0.171	0.014	0.68	0.09	0.011	2.5
OCTOBER	7.50		0.010	<0.001	0.71	0.06	0.002	7.8

Water quality monitoring data for the BUOY LINE AT THE DAM on Cascade Reservoir during 1988.

Date	Sample depth (meters)	Chloro. A (µg/L)	T. Ammonia (mg/L)	NO2 + NO3 (mg/L)	T. Nitrogen (mg/L)	T. Phos. (mg/L)	Ortho Phos. (mg/L)	Diss. Oxygen (mg/L)
JUNE	2.0	17.8	0.041	<0.001	0.60	0.05	0.005	9.0
	17.4		0.078	0.029	0.35	0.06	0.015	5.8
JULY	2.0	17.3	0.068	0.013	0.48	<0.05	0.003	9.7
	15.0		0.312	<0.001	0.6	0.13	0.048	0.5
AUGUST	1.0	42.2	0.021	0.043	1.06	0.05	0.004	8.0
	14.8		0.526	0.016	1.03	0.33	0.110	0.5
OCTOBER	1.0	55.1	0.013	0.003	1.03	0.07	0.002	8.8
	15.5		0.163	0.009	0.75	0.06	0.014	4.5

BUOY LINE AT THE DAM (Secchi disk depth)

Date	Secchi depth (meters)	Chloro. A (µg/L)	T. Ammonia (mg/L)	NO2 + NO3 (mg/L)	T. Nitrogen (mg/L)	T. Phos. (mg/L)	Ortho Phos. (mg/L)	Diss. Oxygen (mg/L)
JUNE	2.0	17.8	0.041	<0.001	0.60	0.05	0.005	9.0
JULY	2.0	17.3	0.068	0.013	0.48	<0.05	0.003	9.7
AUGUST	1.0	42.2	0.021	0.043	1.06	0.05	0.004	8.0
OCTOBER	1.0	55.1	0.013	0.003	1.03	0.07	0.002	8.8

BUOY LINE AT THE DAM (One meter off bottom)

Date	Sample depth (meters)		T. Ammonia (mg/L)	NO2 + NO3 (mg/L)	T. Nitrogen (mg/L)	T. Phos. (mg/L)	Ortho Phos. (mg/L)	Diss. Oxygen (mg/L)
JUNE	17.4		0.078	0.029	0.35	0.06	0.015	5.8
JULY	15.0		0.312	<0.001	0.60	0.13	0.048	0.5
AUGUST	14.8		0.526	0.016	1.03	0.33	0.110	0.5
OCTOBER	15.5		0.163	0.009	0.75	0.06	0.014	4.5